Seismic Site Response at CentrePort, Wellington

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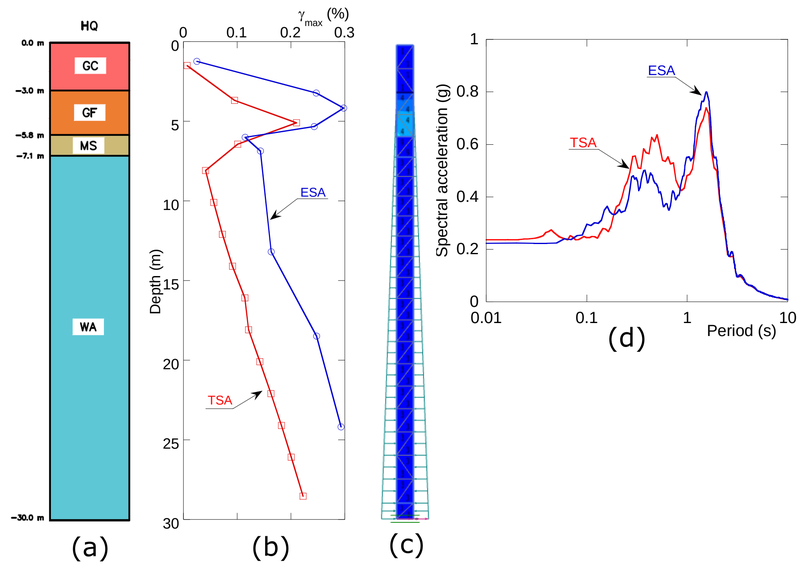
Background

The Port of Wellington (CentrePort) is a key lifeline located on the Wellington Waterfront. CentrePort is situated on land reclaimed in stages between the 1880's and the 1970's. The land was reclaimed using end-tipped quarry fill (sand-silt-gravel mixture) and hydraulic fill pumped from the seabed (sands and silts). The reclamation fill varies in depth from approximately 5 m to more than 20 m. As such, CentrePort is located on fill of varying types, ages and depths as well as various locations within the Thorndon Basin.

This study aimed to quantify seismic site response at CentrePort. Five precincts were chosen to represent the variation in ground conditions and distance from the basin edge. 1D total stress (TSA) and effective stress (ESA) site response analyses were conducted on representative soil profiles from each precinct to assess the influence of ground conditions on the surface motion. The deconvoluted motion from the 2016 M_w7.8 Kaikōura earthquake, which caused severe liquefaction and associated damages at CentrePort, was input to the analysis. The motion used for the deconvolution was recorded at a site that did not manifest liquefaction.

Figure 1: *CentrePort Piptea site, green regions show the five precincts considered in the site response analysis*

Harbour Quays (HQ)



Key features:

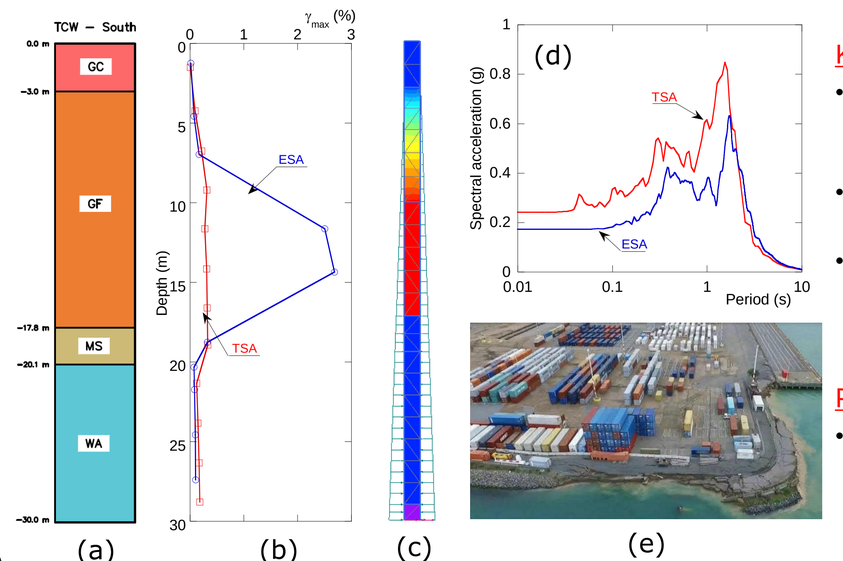
- Old gravelly reclamation (1880s – 1910s)
- Gravelly fill approx. 3 m – 5 m thick
- No to minor liquefaction manifestation in the Kaikōura earthquake

Preliminary results:

- Minor excess pore water pressure build-up in ESA
- Similar response in TSA and ESA

Figure 2: *HQ site response (a) soil profile; (b) maximum shear strain; (c) excess pore water pressure (red – r_u=1.0, blue - r_u=0); (d) response spectra*

Thorndon Container Wharf–South (TCW-S)



Key features:

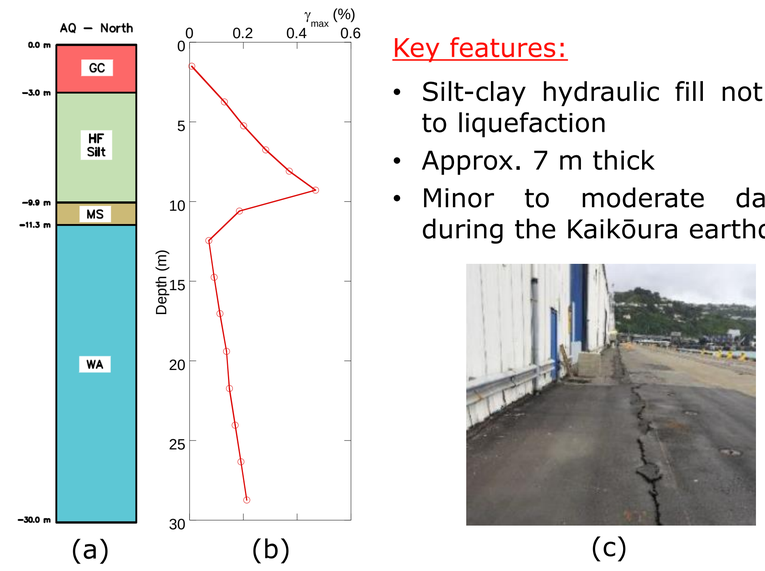
- Recent gravelly reclamation (1960s – 1970s)
- Gravelly fill approx. 15 m – 20 m thick
- Severe soil ejecta and lateral spreading in the Kaikōura earthquake

Preliminary results:

- Liquefaction triggered in ESA, which results in a different site response to that predicted by TSA

Figure 3: *TCW-S site response (a) soil profile; (b) maximum shear strain; (c) excess pore water pressure (red – r_u=1.0, blue - r_u=0); (d) response spectra; (e) liquefaction manifestation*

Aotea Quay-North (AQ-N)



Key features:

- Silt-clay hydraulic fill not prone to liquefaction
- Approx. 7 m thick
- Minor to moderate damages during the Kaikōura earthquake

Figure 4: *AQ-N site response (a) soil profile; (b) maximum shear strain; (c) damage in 2016 Kaikōura earthquake (T&T, 2017)*

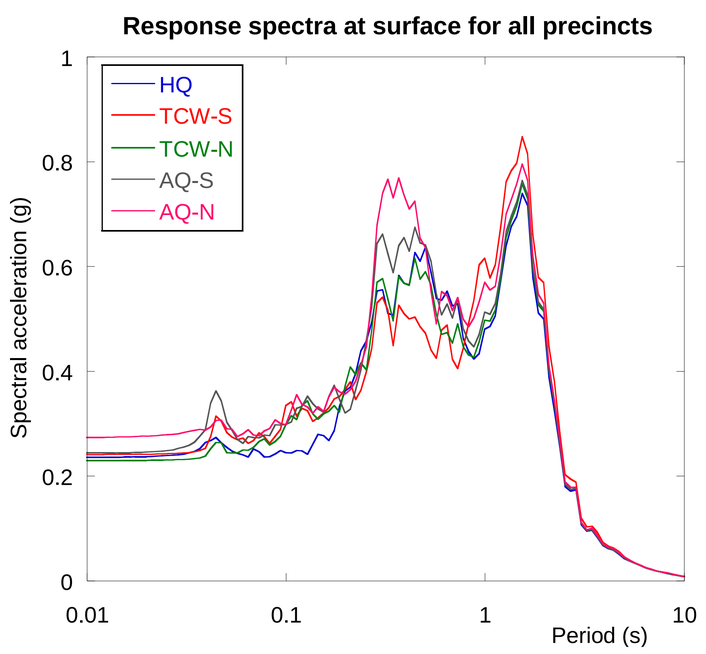
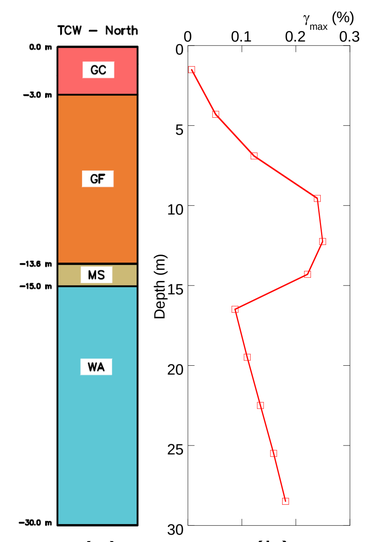


Figure 5: *Surface response spectra for all five precincts with Kaikōura deconvoluted motion input at the base*

Thorndon Container Wharf-North (TCW-N)

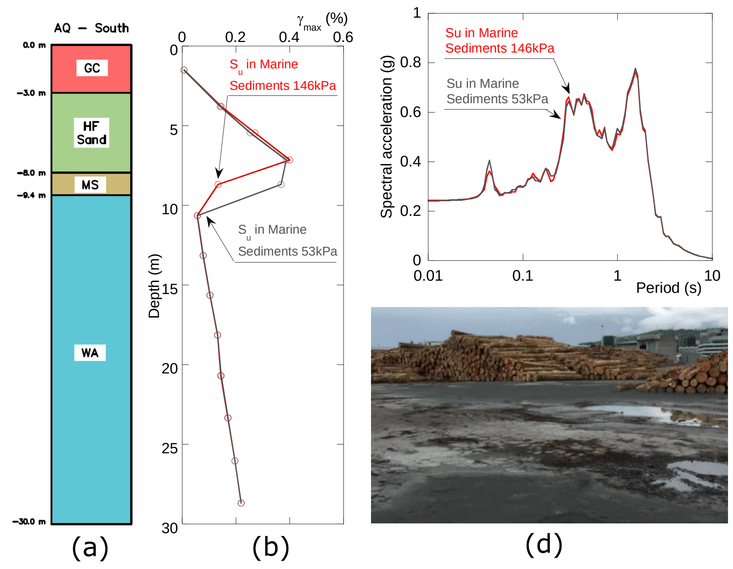


Key features:

- Recent (1960s-1970s) gravelly fill
- Approx. 10 m thick
- Moderate to severe manifestation in the Kaikoura earthquake

Figure 6: *TCW-N site response (a) soil profile; (b) maximum shear strain; (c) liquefaction manifestation (Cubrinovski et al., 2017)*

Aotea Quay-South (AQ-S)



Key features:

- Sand-silt hydraulic fill
- Approximately 5 m thick
- Sandy ejecta after the Kaikōura earthquake
- The shear strength of the marine sediments is unknown (this is also the case for the other precincts)

Results:

- Changing the shear strength of the marine sediment effects the development of shear strains. This is important for design as old seawalls may be founded on this layer.

Figure 7: *AQ-S site response (a) soil profile; (b) maximum shear strain; (c) response spectra; (d) liquefaction manifestation (Cubrinovski et al., 2017)*

Glossary of Soil Units

GC – Gravelly Crust, approximately 3m dense gravelly fill which overlies the whole site.
GF – Gravelly Fill, loose gravel-sand-silt mix present at TCW-N, TCW-S and HQ. The gravelly fill is sandier at HQ.
HF – Hydraulic Fill, this fill was pumped from the existing seabed and is present at AQ-N and AQ-S. There are two types of hydraulic fill, a sand-silt fill (HF Sand) and a silt-clay fill (HF Silt).
MS – Marine Sediment, this unit underlies the reclamation and is a mix of sands, silts, clays and shells.
WA – Wellington Alluvium, this unit underlies the marine sediment and consists of interlayered gravel, sand, silt and clay.

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References:

Cubrinovski, M., Bray, J., de la Torre, C., Olsen, M., Bradley, B., Chiaro, G., Stocks, E., Wotherspoon, L. 2017. "*Liquefaction effects and associated damages observed at the Wellington CentrePort from the 2016 Kaikōura earthquake*". Bulletin of the New Zealand Society for Earthquake Engineering, Vol. 50(2).

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